



DYNA3D calculation of the crush-up upon impact of the nose cone of the B83 strategic bomb (above). Simulations were in excellent agreement with the results of experiments, such as this drop test with a B83 test unit landing on a rigid steel plate (left). Use of DYNA3D accelerated the B83 development program and lowered costs by reducing the number of actual crash-test experiments needed.

## From Swords to Plowshares with DYNA3D

In 1982, a growing list of users benefited from the publication of the first *User's Manual for DYNA3D*. This three-dimensional computer code was developed by Laboratory mechanical engineers to meet the needs of the nuclear weapons program, and it grew to become a remarkable “swords to plowshares” story. Interest in DYNA3D rapidly expanded from a manual to an international conference on the code’s applicability to a wide range of structural analysis problems. The computer code has been used by industry for making everything from safer planes, trains, and automobiles to better beer cans.

Much of the early incentive to develop DYNA3D, short for dynamics in three dimensions, arose from challenges presented by the B83 program. The B83 nuclear bomb was to be released from a low-flying aircraft, and even though it was to be retarded by a parachute, the bomb would have to survive an impact with the ground or whatever irregular structure it hit at up to 75 miles per hour. Lawrence Livermore and Sandia national laboratories needed an affordable program of tests and simulations to design the B83 and certify its crashworthiness. DYNA3D was used to model the structural performance of the B83, a complex design using a wide variety of materials, and it saved millions of dollars and years of time.

The code DYNA3D soon began spreading to private industry in one of the Laboratory’s best examples of technology transfer of software. An unclassified code, DYNA3D’s list of current or one-time industrial users reads like a “Who’s Who” of major firms—General Motors, Daimler-Chrysler, Alcoa, General Electric, Lockheed Missiles and Space, General Dynamics, Boeing Commercial Airplane Group, Adolph Coors Co., Rockwell International, and FMC Corp. For example, General Motors and Daimler-Chrysler have run DYNA3D to help design safer cars; GE Aircraft Engines has operated the code to design jet engine fan blades; and, in 1991, a British engineering firm used the code to study a London train mishap that killed two people and injured 512 others.

At times, upwards of 300 companies have used the code to model their systems before they were built.

A 1993 study found that DYNA3D and DYNA-like programs conservatively save U.S. industry \$350 million annually. As one aerospace engineer stated, “DYNA is what Hershey is to chocolate bars and Kleenex is to tissue. People don’t ask for a (dynamic) finite element code; they ask for a DYNA-like code.”

Since work started on it in 1976, DYNA3D has blossomed from a small 5,000-line computer code into a 150,000-line package. Another version of DYNA3D for parallel computers, called ParaDyn, went into production use in 2000.



With the first Cray 1 arriving in 1979, Cray Research was the principal provider of mainframe machines to the Laboratory until the transformation to massively parallel computing in the 1990s.

### Getting to the Heart of the Matter

In the early 1990s, as bioengineers looked to computer modeling to better understand complex human health problems, some turned to DYNA3D for help. One researcher, in a study associated with Duke University Medical Center, used the Livermore computer code to simulate the experimental response of arteries to balloon angioplasty. Other researchers employed DYNA3D to undertake studies showing the effect of impacts on the human chest and helmets. In addition, DYNA3D was even used in the design of some medical equipment.